

## TILLAGE AND RAINFALL EFFECTS UPON PRODUCTIVITY OF A WINTER WHEAT-DRY PEA ROTATION

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### Introduction

Fresh peas (*Pisum sativum* L.) are grown under dryland conditions near the Blue Mountains of northeastern Oregon and southeastern Washington. During recent decades, fresh-pea acreage has declined due to reduced local market demand and increased international competition. From 1978 to 1987, total fresh-pea acreage in the inland Pacific Northwest decreased from 58,000 acres to 37,500 acres (Kraft et al., 1991). During the past fifty years, fresh-pea yields have increased little and remain highly variable. This is due to abiotic stresses, including unfavorable rainfall and high temperature (Pumphrey et al., 1979), and to biotic stresses, including diseases caused by *Fusarium solani*, *Pythium* spp., and *Aphanomyces* (Allmaras et al., 1987).

As mean annual precipitation in this region decreases to less than approximately 18 in., winter wheat (*Triticum aestivum* L)/fresh-pea rotations under dryland conditions are gradually replaced by winter wheat/summer fallow rotations. The deleterious effects of summer fallowing on the physical and chemical properties of soil and, in some cases, upon nitrate leaching, were documented long ago (Stephens, 1939; Smith et al., 1946), and have been repeatedly confirmed (e.g., Duff et al., 1995).

Where rainfall amount is marginal for fresh-pea production, dry field peas offer a potential alternative to summer fallowing. Although dry peas are grown in the Palouse region of Washington and Idaho, they are currently seldom grown in this portion of the inland Pacific Northwest. The potential benefits of growing dry peas instead of

summer fallowing include the addition of increased organic residue, the biological fixation of N, and erosion protection (Beck et al., 1991). Substituting legumes for fallow would also reduce the downward movement of water in the soil, and thereby counteract nutrient leaching. Additionally, similar to fresh peas, dry peas would aid in the control of weeds and disease associated with wheat monocultures. Even in the wetter zones, dry peas may provide an alternative to fresh peas if market opportunities (e.g., availability of contracts from packing companies) are poor because they have broader market opportunities related to both domestic and foreign demand (Muehlbauer et al., 1983).

The potential for soil-water erosion is great in many parts of the inland Pacific Northwest because of steep slopes and predominantly winter rainfall falling on frozen soils (Pikul et al., 1993). Despite this fact, many farmers continue to use conventional clean-tillage to reduce heavy crop residues and to help control insects, pathogens, and weeds. A common tillage sequence for dry pea production in the Palouse area includes plowing, harrowing, cultivating with a harrow, two more harrowings, planting, and packing the soil with a roller and attached harrow (Hoag et al., 1984). There exists, therefore, a need to reduce rates of soil degradation without adversely affecting the production levels of winter wheat/pea cropping systems. Tillage systems that maintain residue cover, especially during the winter months, are recognized as important methods of reducing soil degradation and erosion. Young et al. (1994b) cite estimates that conservation tillage could reduce soil erosion by 35 percent in much of the inland

Pacific Northwest. This would enable many farmers to meet conservation compliance of the US Food Security Act of 1985 and subsequent legislation. According to Young et al. (1994a), the success of conservation tillage systems in the inland Pacific Northwest has been limited largely by lack of weed control.

The purpose of this study was to evaluate the agronomic performance of a winter wheat/dry pea rotation under four different tillage systems in a rainfall zone considered marginal for fresh pea production.

### Materials and Methods

Data were gathered from one of several long-term studies located at the Columbia Basin Agricultural Research Center, near Pendleton, OR, where mean annual rainfall was 16 inches. From 1967 to 1991, fresh peas were grown in rotation with wheat. Beginning in 1992, dry peas were used instead of fresh peas.

The experimental design was a split plot with four replications. Each replicate contained eight plots (two crops  $\times$  four tillage treatments). The location of peas and wheat within a replicate alternated from year to year. Individual plot size was 24  $\times$  120 ft.

Semi-dwarf soft white winter wheat (cv. Stephens) was seeded as soon after October 10 as soil moisture was sufficient for germination and early crop growth. Dry peas (cv. Columbia) were seeded in late March or early April and harvested in July.

Wheat received 80 lb. N/acre as ammonium nitrate (34-0-0) broadcast before seeding. Peas traditionally received 20 lb. N/acre broadcast every second pea crop as ammonium phosphate-sulfate (16-20-0-14S).

The primary tillage treatments for wheat and pea residue are summarized in Table 1.

Table 1. Primary tillage treatments for wheat and pea residue at Columbia Basin Agricultural Research Center, 1990–1997.

Tillage treatment	Wheat stubble	Pea vines
1. Max till	Fall disk	Fall disk/hisel
2. Fall till	Fall plow	Fall plow
3. Spring till	Spring plow	Fall plow
4. Min till	Fall skewtread	Summer sweep

Additional details on secondary tillages are given below.

#### *Treatment 1, “Max Till”*

Wheat stubble was disked twice at a depth of 4 in. in the fall. In the spring, plots were sprayed, then swept once with a noble sweep at a depth of 1 in., and then rod-weeded with a Calkins rod. Pea vines were chisel-plowed with a JD chisel twice to a depth of 12–15 in. in the fall. Plots were sprayed if necessary and then rod-weeded twice to a depth of 1 in. before seeding.

#### *Treatment 2, “Fall Till”*

Wheat stubble was moldboard-plowed in the fall to a depth of 8–10 in. In the spring, plots were sprayed, spring-toothed twice to a depth of 2–3 in., and roller-harrowed if necessary. Pea vines were moldboard-plowed in the summer to a depth of 8–10 in., sprayed if necessary, tilled twice with a light disc harrow 2–4 in. deep, and roller-harrowed to reduce clods.

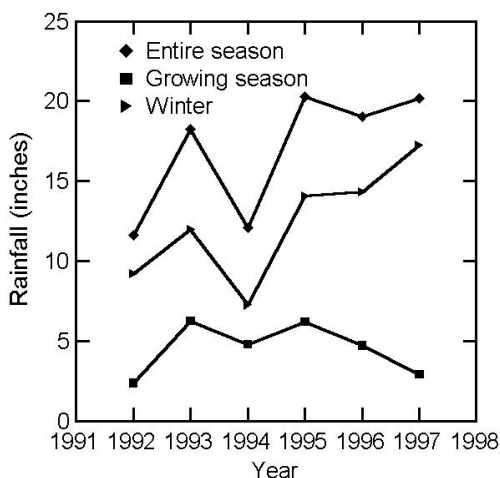
#### *Treatment 3, “Spring Till”*

Wheat stubble was sprayed before being spring plowed. Secondary tillage was the same as treatment 2. Pea vines were also managed as in treatment 2.

#### *Treatment 4, "Min Till"*

Wheat stubble was skew-treaded once or twice to a depth of 1 in. in the fall, swept with a Noble Sweep once to a depth of 1 in., and rod-weeded once with a Calkins to a depth of 1 in. Stubble was busted once with a rotary mower after harvest and before skew-treading until 1996, when this operation was discontinued. Pea vines were skew-treaded 2–3 times in the summer to a depth of 1 in.. In the spring, plots were sprayed if necessary, and rod-weeded twice to a depth of 1 in. Pea vines were sprayed in the spring before secondary tillage.

Analysis of variance was made once using year and tillage as factors. Total winter (October through March) and growing season (April through July) rainfalls were used as covariates in a second analysis of variance. This was because of the heavy dependence of pea- and wheat-yield upon rainfall amount and distribution, and because odd years during the study tended coincidentally to be much wetter than even years. For the years 1990 through 1997, winter rainfall was negatively correlated with growing season rainfall (Fig. 1) and,



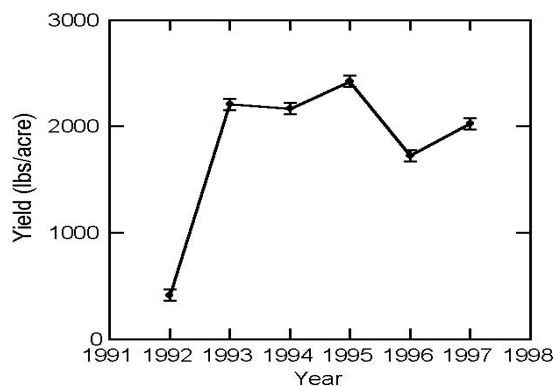
**Figure 1.** Winter (October–March), growing season (April–July) and entire season (Winter+growing season) rainfall amounts at Pendleton Experiment Station, 1990–1997.

inconsistent with larger trends of the past thirty years (Rasmussen et al., 1998), gradually increased during the span of this study.

Grain protein content of wheat was calculated from percent nitrogen and standard regression equations.

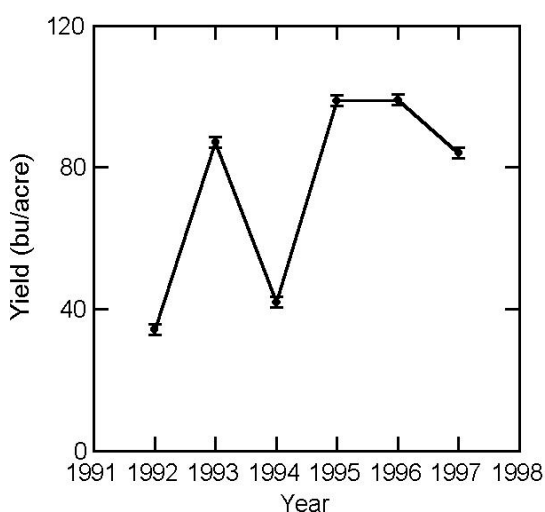
### Results

Wheat and pea yields varied widely from year-to year, reflecting such environmental variables as heat and rainfall amount and distribution (Pumphrey et al., 1979). Pea yields were very low in 1992 (Fig. 2), when growing season rainfall was low (Fig. 1).



**Figure 2.** Dry pea yields from a winter wheat/dry pea rotation at the Pendleton Experiment Station

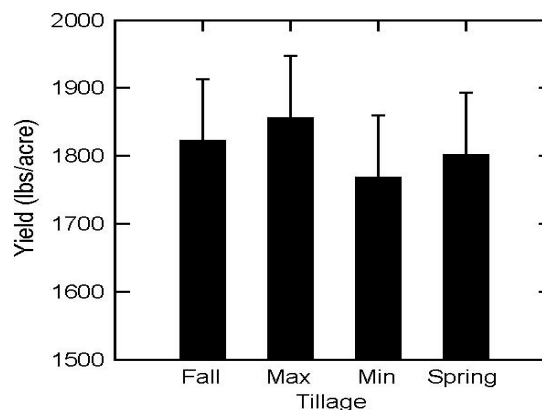
Pea yield was less affected by low growing season rainfall in 1997, presumably because of high winter rainfall. For wheat, 1992 and 1994, which were dry in terms of total and winter rainfall, were associated with low yields (Fig. 3).



**Figure 3.** Winter wheat yield from a winter wheat/dry pea rotation at the Pendleton Experiment Station.

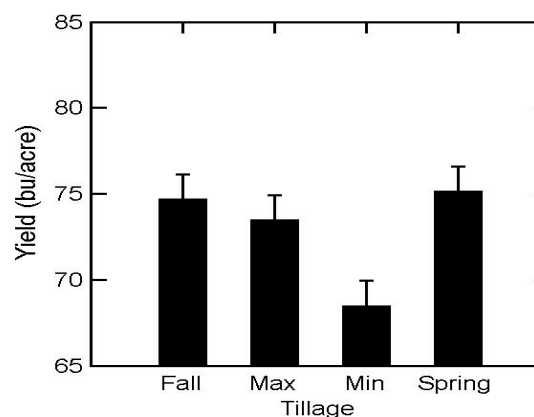
Analyses of variance models using year and tillage as factors revealed no significant effect of tillage upon pea yields, and a significant tillage  $\times$  year interaction, indicating that the ranking among tillage treatments changed from year-to-year. For wheat, there was also a tillage  $\times$  year interaction, as well as a significant effect of tillage. Analysis of variance using winter and growing season rainfalls as covariates revealed that by far the most important yield-determining factor was rainfall amount and distribution. Sums of squares of these data suggest that, while both crops were highly influenced by growing season and winter rainfall, wheat yield was more sensitive to winter rainfall, whereas pea yield was more sensitive to growing season rainfall.

Peas yield was highly variable despite correcting for rainfall, and there was no significant effect of tillage upon yield (Fig. 4).



**Figure 4.** Dry pea yields as affected by four tillage systems at the Pendleton Experiment Station, 1992-1997. Winter and growing season rainfalls have been used as covariates. Bars represent one standard error of the mean.

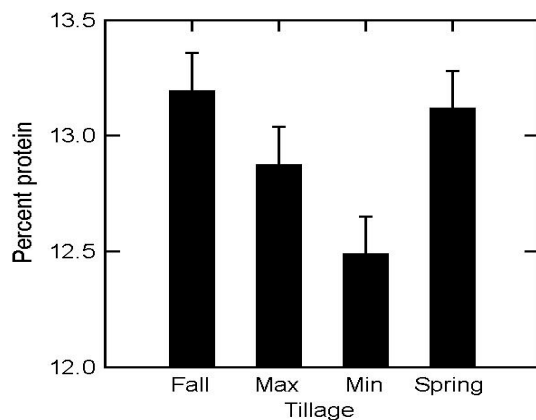
Wheat yield was clearly least in the min-till treatment (Fig. 5), which had the least amount of soil disturbance and the greatest amount of residue left on the surface. There could be a number of



**Figure 5.** Winter wheat yields as affected by four tillage treatments at the Pendleton Experiment Station from 1992 to 1997. Winter and growing season rainfalls have been used as covariates. Bars represent one standard error of the mean.

explanations for this smaller yield, including a visually perceived higher incidence of downy brome (*Bromus tectorum* L.). Young et al. (1994a, b) report that yield response to tillage was dependant upon level of weed control. Smaller wheat yields of the min till

treatment were associated with generally smaller protein percentages (Fig. 6), suggesting that perhaps wheat yield was also



**Figure 6.** Wheat protein content as affected by four tillage treatments in a winter wheat/ dry pea rotation from 1992 to 1997 at the Pendleton Experiment Station.

limited by N supply. It is also possible that greater residue reduced N availability through , for example, greater immobilization of nitrogen by microbial populations.

All in all, our results for dry peas are consistent with those of Pikul et al. (1989), who found no consistent differences in fresh pea production levels despite measurable changes in soil properties due to tillage treatment.

The fact that minimum tillage maintained comparable pea yields suggest wheat yield was also limited by N supply. It is also possible that greater residue reduced N availability through, for example, greater immobilization of nitrogen by microbial populations. All-in-all, our results for dry peas are consistent with those of Pikul et al. (1989), who reported no consistent differences in fresh-pea production levels despite measurable changes in soil properties from tillage treatment. The fact that minimum tillage maintained comparable pea yields suggests that minimum tillage may be an economically viable management option for peas. While Pikul et al. (1989) detected no differences in winter wheat yield from tillage, and Young et al. (1994b) reported increased wheat yields after conservation tillage, our results suggest that conservation tillage resulted in an average yield decrease of six to eight bu/acre. The results underscore the need for effective weed management in conservation tillage systems (Young et al., 1994a), and possibly for increased or differentially applied N.

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